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METHODS OF CROP PRODUCTION AT THE COLBY (KANS.) BRANCH EXPERIMENT STATION, 1915 TO 1929[1]

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In Cooperation with the Kansas Agricultural Experiment Station

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INTRODUCTION

The Colby branch station of the Kansas Agricultural Experiment Station is located just outside the city limits of Colby, in Thomas County, Kans. Thomas County is in the northwestern part of the State, the second county east of the Colorado State line and the second south of the Nebraska State line.

The altitude at Colby is approximately 3,130 feet. Topographically the county is an almost level plain, cut at infrequent intervals by intermittent watercourses. The native sod consists mainly of buffalo and grama grasses.

Winter wheat is the principal crop although corn and barley are grown extensively. This is the chief barley-producing section of the State. Sorghum crops are grown to a limited extent, mainly for forage.

SOIL

The soil of the section of the State in which the Colby branch station is located is designated by the Bureau of Chemistry and Soils of the United States Department of Agriculture as Colby silt loam. This soil is generally typical of the entire northwestern section of Kansas. The usual texture of the surface soil is a silt loam with a small proportion of very fine sand and sufficient clay to give it a slightly compact structure. The color varies from an ashy gray to grayish black,

[1] The following men have had immediate charge of the experiments reported in this circular: The writer from 1914 to May, 1919, and in 1929; Albert Osenbrug from June to December, 1919; John J. Bayles, 1920; and B. F. Barnes from 1921 to 1928, inclusive. John S. Cole assisted in preparing the manuscript.

depending upon the advancement of weathering and the quantity of organic matter present. At the Colby station the grayish-black soil and subsoil range in depth from 18 to 48 inches, the average depth being about 30 inches.

The parent-soil material underlying the subsoil is a loose, mealy, unaltered loess. Where the surface soil merges into the subsoil there is a compact layer of heavy silty loam, usually lighter in color than the surface soil, and ranging in thickness from 2 to 8 inches. It contains varying quantities of carbonate concretions. Below this horizon is the loess, which extends to a depth of many feet.

The soil is easily worked, especially when the proper moisture conditions exist. A coarse surface, which is desirable to prevent soil blowing and to facilitate the penetration of water, can be formed fairly readily by working the soil when it is wet. It plows up somewhat cloddy and lumpy when dry but works down easily after rains.

There seems to be a sufficiency of the essential plant-food elements in the soil, so that moisture rather than soil fertility is the limiting factor in crop production.

CLIMATE

Climatological records have been kept at the Colby station since its inception in 1914. The temperatures are recorded in a standard United States Weather Bureau shelter, and the precipitation is measured in a standard Weather Bureau gage.

The wind velocity is determined from a Robinson 4-cup anemometer exposed at a height of 24 inches. The evaporation is recorded by daily micrometer measurements of the change in the water level in a tank 24 inches deep and 6 feet in diameter sunk to a depth of 20 inches in the ground.

TABLE 1.—*Monthly, seasonal, and annual precipitation at the Colby branch station for the 16-year period 1914–1929 and the 42-year average for Colby from the United States Weather Bureau records from 1888 to 1913 and the Colby station records from 1914 to 1929, inclusive*

[Precipitation in inches. T. = trace]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr.–Sept.	Annual
1914	0.05	0.45	0.21	1.21	3.07	2.32	5.01	1.85	0.52	0.87	T.	0.51	13.98	16.07
1915	.38	1.49	1.43	3.61	4.55	4.03	6.60	4.17	.67	1.10	0.48	.48	23.63	28.99
1916	.55	.05	.33	2.03	1.33	3.15	2.07	1.48	.40	.62	.21	.37	10.46	12.59
1917	.12	.20	.56	1.66	2.01	1.42	3.07	5.78	4.25	.28	.42	.20	18.19	19.97
1918	.77	1.79	1.34	1.05	2.16	.19	1.86	1.88	2.16	2.87	.21	2.63	9.30	18.91
1919	T.	1.57	.59	2.80	2.23	2.47	3.95	.65	2.07	.82	1.63	.19	14.17	18.97
1920	.23	.31	.46	3.74	2.42	5.68	4.19	3.75	2.56	2.71	.27	1.31	22.34	27.63
1921	1.15	.03	.58	1.88	1.85	3.52	4.24	2.23	2.80	.45	.18	.46	16.52	19.37
1922	.18	.35	1.26	4.08	2.55	1.34	2.74	1.38	.43	.08	3.13	.02	12.52	17.54
1923	.05	.18	.88	2.80	6.28	3.27	3.46	3.55	1.87	3.33	.12	.75	21.23	26.54
1924	.22	1.82	1.78	.48	1.30	.80	1.77	3.09	1.78	.95	.14	1.97	9.22	16.10
1925	.23	.25	.47	1.44	3.52	1.07	1.50	3.50	2.00	.82	.16	.39	13.03	15.35
1926	.52	.12	.50	.87	2.08	1.57	.57	2.04	.92	.22	.83	.34	8.05	10.58
1927	.11	1.26	1.59	3.51	.43	3.75	2.00	1.87	2.68	.25	.10	.45	14.24	18.00
1928	T.	.48	1.53	.89	4.53	5.40	2.66	1.19	.29	2.06	.65	.06	14.96	19.74
1929	.06	.76	.13	3.15	3.25	1.96	1.07	1.13	3.02	1.70	1.81	.02	13.58	18.06
Average:														
1914–1929	.29	.69	.85	2.20	2.72	2.62	2.92	2.47	1.78	1.20	.65	.63	14.71	19.03
1888–1929	.29	.60	.85	2.19	2.43	2.95	2.61	2.30	1.59	1.06	.58	.57	14.07	18.02

Precipitation and temperature records for Colby since 1888 are available from the United States Weather Bureau. The Colby station records of the monthly, seasonal (April 1 to September 30), and annual precipitation for the 16 years from 1914 to 1929, together with the averages for the period, are shown in Table 1. Averages from the Weather Bureau records and the Colby station records covering a period of 42 years from 1888 to 1929 are also included.

The average annual precipitation for the 42 years from 1888 to 1929 has been 18.02 inches and that for the 16-year period since the establishment of the experiment station in 1914, 19.03 inches. The seasonal (April 1 to September 30) precipitation for the 16 years has averaged 14.71 inches. More than three-fourths of the annual precipitation falls during this 6-month period, which approximates the growing season.

There is a great fluctuation in the precipitation. During the 42-year period the precipitation has ranged from 6.62 inches in 1910 to 29.54 inches in 1897. The standard deviation is 5.13 inches, and the coefficient of variation is 0.28.

Table 2 shows the evaporation from a free-water surface, the wind velocity, and the mean monthly temperature for the 6-month period from April 1 to September 30. The evaporation is dependent upon various factors, including temperature, wind velocity, and humidity of the atmosphere, and is something of an index to the climatic factors, other than precipitation, that influence crop production. The evaporation tends to vary inversely with the precipitation. The average evaporation for the 6-month period from April 1 to September 30 for the 16 years from 1914 to 1929 was 41.376 inches. It ranged from 31.657 inches in 1915 to 49.287 inches in 1926. It varied from 1.34 times the precipitation during the same months in 1915 to 6.12 times the precipitation in 1926.

The average wind velocity for the 6-month period was 7 miles per hour for the 16 years. The highest monthly average was 8.8 miles per hour for April, and the lowest was 5.6 miles for August. High wind velocities often cause damage by soil blowing during the spring months. Hot winds during the summer occasionally injure growing crops.

The mean temperature for the 6-month period from April 1 to September 30 averaged 65° F. The mean maximum for the same period was 70°, and the mean minimum was 51°. As a rule, the day temperatures are rather high during the summer, but the nights are comparatively cool.

During the period from 1893 to 1929 for which records are available the average length of the frost-free period was 158 days. The average date of the last killing frost in the spring was May 1, and the average date of the first killing frost in the fall was October 6. The earliest date of the last killing frost in the spring was April 13, in 1900 and 1913, and the latest was May 26, in 1901. The earliest date of the first killing frost in the fall was September 7, in 1898, and the latest was November 2, in 1907. The shortest frost-free period since the station was established was 135 days, in 1916, and the longest was 172 days, in 1923 and 1929. The data for each year from 1914 to 1929, inclusive, are given in Table 3.

TABLE 2.—*Monthly evaporation, wind velocity, and mean temperature at the Colby branch station from April to September, inclusive, for the 16 years 1914–1929*

EVAPORATION (INCHES)

Year	April	May	June	July	August	September	Seasonal, April to September
1914	[1] 4.587	[1] 5.737	8.975	7.972	8.880	7.592	43.743
1915	4.023	5.429	5.843	5.980	5.444	4.938	31.657
1916	4.415	7.065	7.153	11.231	8.830	6.838	45.532
1917	4.362	5.377	7.950	9.579	6.741	4.711	38.720
1918	3.753	7.049	8.092	8.457	9.214	4.810	41.375
1919	3.540	5.023	6.607	9.194	8.857	6.420	39.641
1920	3.063	4.064	6.812	7.504	5.261	[1] 6.017	32.721
1921	5.277	7.030	6.033	8.720	6.409	5.894	39.363
1922	3.535	6.499	8.359	9.057	8.295	6.840	42.585
1923	5.431	5.259	6.609	7.341	6.887	5.844	37.371
1924	5.610	6.712	7.871	10.194	8.637	6.282	45.306
1925	6.142	6.697	10.395	10.892	8.471	6.371	48.968
1926	5.341	7.312	8.520	11.476	10.353	6.285	49.287
1927	5.017	8.940	7.063	9.037	6.014	7.154	43.225
1928	6.118	5.948	5.228	7.364	8.770	7.153	40.581
1929	5.804	5.102	7.049	9.982	8.217	5.782	41.936
Average	4.751	6.203	7.410	8.999	7.830	6.183	41.376

WIND VELOCITY (MILES PER HOUR)

1914			7.2	4.8	5.9	6.2	
1915	7.4	7.6	6.8	5.5	3.7	5.5	
1916	8.1	8.8	7.4	8.1	6.8	6.7	
1917	9.3	8.8	8.2	6.3	5.6	5.5	
1918	10.3	10.0	6.2	6.8	7.0	6.4	
1919	9.0	7.1	5.5	5.9	4.7	5.6	
1920	9.5	8.0	6.4	3.8	3.4		
1921	9.2	9.6	5.2	5.7	4.2	4.9	
1922	9.0	7.0	6.9	6.0	5.3	6.2	
1923		8.2	7.5	4.5	4.0	5.3	
1924	8.1	7.0	7.3	8.0	7.2	7.6	
1925	8.8	7.5	9.1	6.3	7.0	7.1	
1926	7.5	8.9	7.0	8.0	7.1	9.1	
1927	8.8	10.8	7.7	6.1	5.2	7.4	
1928	8.7	6.6	6.4	5.4	6.7	5.7	
1929	9.1	8.6	6.1	6.8	5.3	7.4	
Average	8.8	8.3	6.9	6.1	5.6	6.4	

MEAN TEMPERATURE (° F.)

1914	53	60	73	75	75	68	67
1915	54	55	64	71	67	64	63
1916	46	60	67	79	75	64	65
1917	46	54	69	77	70	66	64
1918	44	62	75	75	77	59	65
1919	48	57	68	76	75	69	66
1920	43	58	68	74	69	67	63
1921	49	61	69	76	74	67	66
1922	48	59	72	75	77	69	67
1923	49	56	68	74	71	64	64
1924	50	54	70	74	75	61	64
1925	54	60	75	77	74	67	68
1926	47	63	70	77	77	64	66
1927	53	63	67	75	69	66	66
1928	47	61	62	74	73	64	64
1929	51	58	69	79	77	61	66
Average	49	59	69	76	73	65	65

[1] Interpolated.

TABLE 3.—*Dates of the last killing frost in the spring and the first in the fall and the number of frost-free days at the Colby branch station for the 16 years 1914–1929*

Year	Last frost in spring	First frost in fall	Frost-free period	Year	Last frost in spring	First frost in fall	Frost-free period
			Days				*Days*
1914	May 13	Oct. 14	154	1923	Apr. 24	Oct. 13	172
1915	May 20	Oct. 4	137	1924	May 14	Sept. 28	137
1916	May 15	Sept. 27	135	1925	Apr. 30	Oct. 18	171
1917	May 7	Oct. 7	153	1926	Apr. 28	Sept. 25	150
1918	May 9	Oct. 25	169	1927	Apr. 21	Oct. 8	170
1919	Apr. 24	Oct. 9	168	1928	Apr. 22	Sept. 25	156
1920	Apr. 29	Sept. 29	153	1929	May 1	Oct. 20	172
1921	Apr. 28	Oct. 9	164				
1922	do	Oct. 7	162	Average	May 2	Oct. 7	158

ROTATION AND TILLAGE EXPERIMENTS

Field experiments in crop rotation and cultural methods have been conducted at the Colby station by the Division of Dry Land Agriculture of the Bureau of Plant Industry, United States Department

FIGURE 1.—General view of experimental field at the Colby branch station. (Photographed in July, 1917)

of Agriculture, in cooperation with the Kansas State Agricultural Experiment Station. The experiment field covers approximately 25 acres. It is nearly level with a slight slope toward the east. Heavy rains drain off readily, but little soil washing takes place. According to the best information available, the sod was broken about 1885. It was allowed to go back in the early nineties and was broken again in 1905. Since 1905 the land has been farmed continuously. A general view of the field is shown in Figure 1.

The work was started in 1914 with 160 plots. Later 20 more were added. Of the 180 plots, 46 are in winter wheat, 10 in spring wheat, 7 in barley, 12 in oats, 18 in corn, 35 in milo, 4 in feterita, 3 in kafir, 1 in beans, 3 in rye and 1 in peas for green manure, and 40 are fallow each year.

EXPERIMENTAL METHODS

Experiments are conducted on tenth-acre plots, 2 by 8 rods, separated on the ends by 20-foot roadways and on the sides by 4-foot alleys. The roadways and alleys are cultivated and kept clean.

Ordinary horse-drawn farm machinery is used for all operations, and the field conditions incident to the cultural methods under trial are maintained as closely as possible. The small grains are harvested with a binder. Corn and sorghum crops are cut with a corn binder. Bean vines are pulled up when the beans are ripe, and the rye and peas for green manure are plowed under when they begin to bloom. The fallow plots, except those devoted to methods of fallow, are plowed to a depth of between 7 and 8 inches, usually in May, and then kept clean until seeding time.

The staple crops—winter wheat, spring wheat, oats, barley, corn, milo, and kafir—are grown continuously on the same land, on fall plowing and spring plowing, and alternating with fallow. Late fall plowing takes the place of spring plowing for winter wheat. All these crops except kafir are also grown in rotations with different cultural

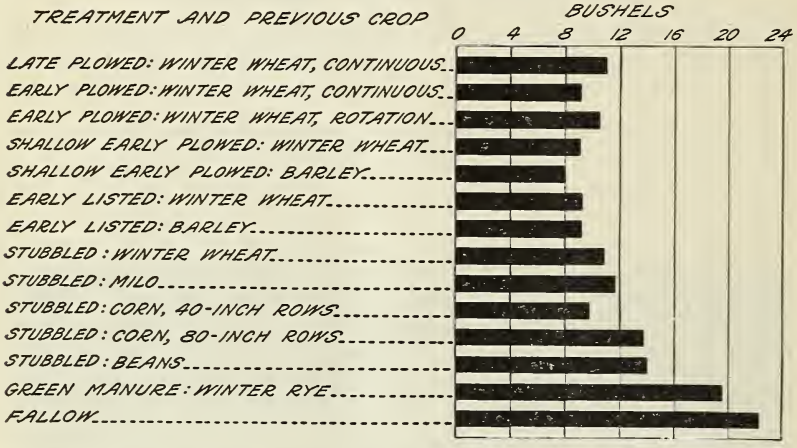

FIGURE 2.—Average acre yields of winter wheat grown by different methods for the 10 years 1920–1929

treatments. Barnyard manure is used on a number of plots. Straw is used on one plot as a top-dressing for winter wheat. Four plots are planted to feterita with a lister. One plot of beans is grown alternating with winter wheat.

A standard variety of each crop is used, and all plots of a given crop are seeded with the same variety. The varieties used for the various crops are as follows: Winter wheat, Turkey in 1914, 1915, and 1916, and Kanred since 1916; spring wheat, Beloturka durum; oats, Kherson; barley, local 6-row; corn, Colby Bloody Butcher; milo, Dwarf Yellow; kafir, Dwarf Blackhull from 1914 to 1921, inclusive, and Dawn since 1921; feterita, common; and beans, pinto.

Variety tests conducted at the station indicate that, with the possible exception of oats, the varieties used have been among the highest yielders. Since the Kanota variety of oats was introduced, it has averaged appreciably higher yields than the Kherson used in these experiments.

In the discussion of results the yields for the first year of the experiment are not used.

RESULTS WITH WINTER WHEAT

Winter wheat has been grown since 1914 by different methods, both continuously and in rotation with other crops.

The yields for the 15 years from 1915 to 1929 are given in Table 4, and averages for the 10 years from 1920 to 1929 are shown in Figure 2. Five methods have been under trial for the entire period. The 15-year average yields were as follows: 21.6 bushels on fallow, 19.6 bushels on rye green manure, 12.9 bushels on alternate-row corn ground, 11 bushels on late-plowed wheat stubble, and 9.2 bushels on early-plowed wheat stubble.

TABLE 4.—*Yields of winter wheat grown by different methods at the Colby branch station, 1915–1929*

Treatment and previous crop	Number of plots averaged	Acre yield (bushels)															Average	
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1915 to 1929	1920 to 1929
Late plowed:																		
Winter wheat (continuous)	1	9.3	9.0	0	11.2	25.8	20.0	23.8	12.4	10.0	10.5	5.2	1.7	1.7	19.8	5.3	11.0	11.0
Early plowed:																		
Winter wheat (continuous)	1	18.7	18.5	0	5.3	7.5	15.0	13.2	15.3	5.0	8.5	5.5	1.3	.7	18.3	5.8	9.2	8.9
Winter wheat (rotation)	2	----	----	0	11.9	13.4	15.3	13.8	15.9	9.5	13.8	6.6	2.9	1.6	16.3	9.1	[1] 10.0	10.5
Shallow early plowed:																		
Winter wheat	1	----	----	----	----	----	14.8	9.6	14.4	7.8	10.6	7.5	1.3	0	15.0	9.0	----	9.0
Barley	1	----	----	----	----	----	14.2	8.2	12.2	6.8	14.0	2.7	1.0	0	11.8	9.0	----	8.0
Early listed:																		
Winter wheat	1	----	----	----	----	----	14.3	11.1	16.1	6.8	8.1	5.7	3.3	0	16.2	9.7	----	9.1
Barley	1	----	----	----	----	----	14.5	8.7	14.3	6.3	12.7	6.7	.7	0	16.3	9.3	----	9.0
Stubbled in:																		
Winter wheat	1	----	----	0	2.2	22.2	24.2	11.2	10.6	14.3	4.5	6.3	1.5	2.3	22.2	11.3	[1] 10.2	10.8
Milo	1	----	----	0	6.5	31.3	16.0	12.3	7.8	10.8	7.3	21.7	1.3	1.7	23.3	15.3	[1] 11.9	11.8
Corn, 40-inch rows	2	----	----	0	6.0	21.7	16.6	7.8	9.6	8.1	11.5	10.3	1.5	3.1	18.3	10.8	[1] 9.6	9.8
Corn, 80-inch rows	1	16.7	16.7	0	6.5	17.0	30.5	12.5	16.6	6.3	15.6	11.5	4.0	2.5	25.3	12.3	12.9	13.7
Beans	1	----	----	----	----	----	18.8	23.7	17.5	10.7	16.3	12.3	2.0	2.3	22.6	12.3	----	13.9
Green manure:																		
Winter rye	1	22.7	23.3	0	20.7	30.7	27.7	31.2	30.3	8.2	21.4	12.5	17.2	4.8	28.7	14.0	19.6	19.6
Fallow	30	26.2	22.7	0	19.8	33.3	38.1	29.2	26.9	3.6	28.2	22.9	19.0	3.1	34.6	16.1	21.6	22.2
Continuously stubbled:																		
Winter wheat	1	----	----	----	----	----	----	12.6	8.1	15.5	1.1	5.8	2.3	3.3	12.7	5.0	----	[2] 7.4

[1] 13-year average. [2] 9-year average.

The yield given here for fallow is the average of 30 fallow plots, 20 of which are in 3-year rotations of fallow, winter wheat, and milo. Wheat on fallow in a continuous alternation of wheat and fallow on 2 plots adjoining the continuous wheat on early and late plowing averaged 18.2 bushels. Figure 3 shows in the foreground the fallow and wheat on fallow as they appeared July 1, 1930. The methods of fallow will be considered later. Rye for green manure is plowed under when in blossom, and the land is cultivated as a clean fallow during the remainder of the season. The results approach those of a fallow but do not equal them.

The wheat on alternate-rowed corn is in a 4-year rotation. The corn is listed in alternate rows, every other lister furrow being left blank so the rows are 80 inches apart. Wheat is drilled in the corn stubble after the corn has been removed.

Both early and late plowing after wheat were on land continuously cropped to wheat. Early plowing is done as soon as practicable after harvest. The ground is plowed from 7 to 8 inches deep, usually packed with a disk set straight and weighted, and then kept clean of weeds. Late plowing is done just before seeding. It is 3 to 4 inches deep and usually is followed by disking or harrowing to smooth the ground for seeding. The average date of harvest has been July 8, and the average dates of plowing have been July 31 for the early and September 12 for the late.

In 1916 a 2-year rotation, No. 257, of listed milo and winter wheat on milo stubble was started. Two 4-year rotations were started the same year. Rotation 574 is listed corn, winter wheat on corn ground, winter wheat on early fall-plowed wheat stubble, and winter wheat drilled in wheat stubble. Rotation 575 is listed milo, listed corn, winter wheat on corn ground, and winter wheat on early fall-plowed wheat stubble.

The average yield of wheat on milo stubble in rotation 257 for the 13-year period 1917 to 1929 was 11.9 bushels. Average yields

FIGURE 3.—Fallow and winter wheat on fallow at the Colby branch station

for the same period of wheat following corn were 10.4 bushels in rotation 574 and 8.8 bushels in rotation 575. The average of the two is 9.6 bushels, which is 2.3 bushels less than the yield following milo. This is not to be considered as evidence that milo is a better preparation than corn for wheat. A good stand of corn has been secured every year, but the stand of milo sometimes has been so thin that the ground was partially fallow, and the succeeding yield of wheat was comparatively high. The average yield of corn in the two rotations was 17 bushels, and the average yield of milo in rotation 257 was 9.1 bushels.

The three crops of wheat in rotation 574 offer a comparison of three methods of growing wheat that is free of plot differences, because crops grown under the three methods follow one another successively on the four plots in the series in a rotation of corn for one year and wheat for three years. Average acre yields for the 13-year period were: Wheat following corn, 10.4 bushels; wheat on early plowing following wheat, 10.8 bushels; and wheat drilled in wheat stubble, 10.2 bushels. Plowing wheat stubble in this case resulted in an average increase of only 0.6 of a bushel over drilling in the stubble. The yield following corn was slightly less than that following wheat

on early plowing and slightly more than that following wheat without plowing. An advantage that wheat drilled in wheat stubble has over that on plowed ground or in corn stubble is that the wheat stubble catches more snow and prevents soil blowing. It probably also affords more protection in the winter.

Rotation 575 affords a similar comparison of wheat following corn and wheat on early-plowed wheat stubble. The 13-year average yields in this rotation were 8.8 bushels following corn and 9.1 bushels following wheat. The yields were lower than in rotation 574, but they followed the same order.

A 2-year rotation of pinto beans on spring plowing and winter wheat drilled on the bean land was started in 1919. The average yield of wheat in this rotation for the 10 years from 1920 to 1929 was 13.9 bushels. This was the highest yield where wheat was raised following another crop. Beans were grown in 40-inch rows and pulled when ripe. The yields of beans ranged from complete failures to 19.3 bushels per acre and averaged 5 bushels.

The yield of wheat following beans is grouped with that following corn in 80-inch rows. Both are of a higher order than the yields following other crops. This indicates that neither beans in 40-inch rows nor corn in 80-inch rows is sufficiently thick to completely exhaust the soil moisture, and that such cropping partakes something of the nature of a fallow.

Two 4-year rotations were also started in 1919. Rotation 406 is listed corn, barley on disked corn stubble, winter wheat on early-listed barley stubble, and winter wheat on shallow early-plowed wheat stubble. Rotation 407 is listed milo, barley on disked milo stubble, winter wheat on shallow early-plowed barley stubble, and winter wheat on early-listed wheat stubble. Each of the wheat crops in rotation 406 averaged 9 bushels per acre for the 10 years from 1920 to 1929. During the same period the wheat in rotation 407 averaged 8 bushels on shallow early-plowed barley stubble and 9.1 bushels on early-listed wheat stubble. A volunteer growth of barley sometimes used enough soil moisture to weaken materially the wheat in the fall. This volunteer growth was not controlled so well by the shallow plowing in rotation 407 as it was by the listing in rotation 406.

One plot has been drilled to winter wheat each year since 1921 without any tillage whatever of the ground. Figure 4 shows the wheat on this plot as it appeared on July 1, 1930. This plot averaged 7.4 bushels per acre for the nine years from 1921 to 1929. At the end of this period it was rather soddy and hard. During the same years winter wheat grown continuously on late plowing averaged 10 bushels and on early plowing 8.1 bushels per acre.

No. 153 is a 4-year rotation in which winter wheat is grown following winter rye turned under for green manure. The other crops in the rotation are corn and milo. Winter rye is sown in the fall in milo stubble and is turned under when in blossom. The ground is packed after plowing and cultivated as necessary to keep it clean during the summer, its treatment after plowing being the same as that of fallow. The average date of plowing has been June 5, which is six days later than the average date of plowing fallow. The average yield of wheat following the green manure for the 15 years from 1915 to 1929 was 19.6 bushels per acre.

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Near-by plots on fallow in 4-year rotations averaged 20.9, 19.5, 19.4, and 19.4 bushels per acre, respectively. Yields on green manure were similar to those on fallow. The relative behavior in any year seems to depend upon how far the rye depletes the soil moisture before being turned under. Any beneficial effect of the green manure is apparently offset by the loss of the moisture it takes to produce it. If any change is taking place in the soil as a cumulative effect of the green manure, it has not as yet been reflected in the crop yields.

Each year 30 plots of winter wheat are grown on fallow. In all but 3 of the 15 years from 1915 to 1929, the yield of wheat on fallow was higher than that on ground prepared in any other way except with green manure. In 1917 all methods were total failures as a result of drought and winterkilling. In 1923 all other methods outyielded the fallow, because the wheat on it had a low winter survival and rusted. In 1927 wheat was almost a failure regardless of the method of plot preparation used, and the yield on fallow was

FIGURE 4.—The tenth successive crop of winter wheat on land not plowed or otherwise cultivated, at the Colby branch station

equaled or exceeded by that on corn ground, that on the green-manured plots, and that of wheat continuously drilled in the stubble.

The 15-year average yield of all plots on fallow was 21.6 bushels per acre, and the 10-year average from 1920 to 1929 was 22.2 bushels. The only other method producing yields of the same order was rye green manure, which averaged 19.6 bushels for both periods. Green manure is a partial fallow. The next highest yields for the 10 years were 13.9 bushels following beans and 13.7 bushels following corn in 80-inch rows. The beans averaged 5 bushels and the corn 12.4 bushels per acre. The substitution of these crops planted in this manner in place of fallow reduced the following crop of wheat a little more than 8 bushels per acre below the average on fallow. On all other methods the wheat followed a crop of wheat, barley, corn, or milo, and the yields averaged from 8 to 11.8 bushels per acre for the 10 years. The 15-year averages were about the same for the methods that were used during the longer period. Wheat yields on cropped land were generally of the same order and averaged less than half the yields on fallow.

In rotation 156 barnyard manure is applied at the rate of 10 tons per acre before the ground is plowed for fallow. This is in a 4-year

rotation of manured fallow, milo, fallow, and winter wheat. Rotation 155 on the plots across the roadway is exactly the same except that no manure is used. The wheat in these rotations averaged exactly the same, 19.4 bushels, for the 15 years from 1915 to 1929. The milo averaged 25.9 bushels on the manured fallow and 0.4 of a bushel more on the unmanured fallow.

In rotation 554 straw is applied at the rate of 3 tons per acre as a top-dressing late in the fall after the wheat is up. Barnyard manure is applied in a similar manner at the rate of 3 tons per acre in rotation 555 and 6 tons per acre in rotation 556. These are 3-year rotations of fallow, wheat, and milo. Similar adjacent rotations are treated exactly like these except that no top-dressing is applied. The 15-year average yields of the top-dressed plots ranged from 23.4 to 25.2 bushels per acre, and the three averaged 24.1 bushels.

Wheat averaged 26 bushels in the plots of the untreated rotation on one side of these three and 22.4 bushels in the one on the other side. The average of the two is 24.2 bushels, almost the same as the average in the rotations receiving the top-dressing. These results suggest that soil fertility is not a limiting factor in crop production in this section.

To determine the relative effects on the following crops of wheat of different intensities, times, and methods of cultivation of fallow, five methods of fallowing have been under trial. They occupy five pairs of plots designated as H and I, J and K, L and M, N and O, and P and Q. One plot of each pair is in winter wheat each year and the other is fallowed. When plots H, J, L, N, and P are in crop, plots I, K, M, O, and Q are in fallow.

Results are available for the 14 years from 1916 to 1929, but certain of the methods were changed in preparation for the crop of 1922 and succeeding years. The annual yields and the averages for three periods, 1916 to 1921, 1922 to 1929, and 1916 to 1929, are presented in Table 5.

TABLE 5.—*Annual and average yields of winter wheat with different methods of fallow at the Colby branch station, 1916–1929*

Plots	Treatment	Acre yield (bushels)														Average		
		1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1916 to 1921	1922 to 1929	1916 to 1929
H and I	Fall plowed; cultivated immediately.[1]	24.2	0	15.0	24.0	42.7	19.5	32.5	1.5	33.5	21.3	6.5	1.0	30.5	13.0	20.9	17.5	18.9
J and K	Fall plowed; rough first winter.	24.8	0	22.5	21.8	43.2	27.5	31.8	1.7	47.5	19.2	9.5	.5	33.2	13.2	23.3	19.6	21.2
L and M	Spring plowed; late May.[2]	25.8	0	21.0	28.8	38.3	35.8	25.3	1.0	39.9	24.0	8.8	.3	34.7	17.7	25.0	19.0	21.5
N and O	Spring plowed; late June.[2]	27.7	0	24.0	36.7	40.3	38.2	16.6	2.2	33.3	11.5	7.3	.2	20.7	12.3	27.8	13.0	19.4
P and Q	Fall listed	25.7	0	14.2	23.3	40.7	27.2	31.3	2.5	37.8	23.3	14.3	2.3	41.2	14.7	21.9	20.9	21.3

[1] Replowed in June after 1921.
[2] Previous to 1922 the fallow plots in L and M and N and O were plowed on the same date, but the one in L and M received more intensive cultivation than the one in N and O.

In general, the number of cultivations or the length of the period of cultivation, or both, have decreased from H and I through J and K and L and M to N and O, while P and Q have varied from the others in being listed instead of plowed.

Previous to the fallow season of 1921 in preparation for the crop of 1922, the plots to be fallowed in the pairs H and I and J and K were plowed soon after harvest. The one in the pair H and I was worked down with a summer cultivation, but the one in the pair J and K received no cultivation until the following spring. During the fallow summer each received from three to five cultivations with the disk or the spring-tooth harrow.

From 1921 on, the fallow in H and I was replowed on the average date of June 30. The first plowing under this method continued to be early, the average date being August 1, but the plowing for fallow in the pair J and K was delayed until the average date of September 25. The first was worked down in the fall and the other went through the winter rough.

In the pairs L and M and N and O the stubble received no cultivation until it was plowed in the spring or summer of the fallow year following harvest. Previous to preparation for the crop of 1922 both pairs were plowed on the same date in late May or early June. They differed in that the fallow in L and M received from two to four cultivations after plowing, whereas that in N and O received but one or two. No change was made in L and M, but after 1921 the plowing of N and O was delayed from May 22, the average date for L and M, to June 19, on an average. In some years the earlier plowing required more cultivations than the later plowing to keep it free of vegetation.

The method used on L and M is the standard method of fallow in the general experiments. The method of fallow in P and Q is the same as in J and K except that the ground is listed instead of plowed in the fall.

In both the first period of six years and the later period of eight years, H and I averaged less than J and K. The greater amount of work expended on the fallow in H and I resulted in an average decrease of 2.3 bushels of wheat per year for the 14-year period. The decrease was about the same for each of the shorter periods.

J and K with a 14-year average of 21.2 bushels and L and M with an average of 21.5 bushels exhibit no real difference. L and M had slightly the higher yield in the first period and J and K in the second period. The fallow is plowed in the fall in J and K and in the spring in L and M. The economy of labor and the protection afforded by the stubble against soil blowing point to the spring plowing as the more desirable.

During the first six years of the period, when the fallow in N and O was plowed at the same time as in L and M but received fewer cultivations after plowing, the average yield was slightly higher in N and O. During the last eight years the difference in the two methods consisted in the plowing of N and O later than L and M. The effect of delaying the plowing from the average date of May 22 to June 19 was to reduce the yields to the lowest of any method of fallow under trial. The yield on the earlier plowed plots averaged 19 bushels and that on the later plowed plots 13 bushels.

Weeds have not gained much of a start by the time of the earlier plowing, but at the time of the later plowing, in most years, they have

made considerable growth and have used an appreciable quantity of water from the soil. This results in a lower moisture content of the soil at seeding time and in a loose, undesirable seed bed when the summer precipitation is light.

The listing method used in P and Q compares most closely with the plowing method used in J and K in time and number of cultivations, and the average yields for the 14-year period are almost exactly the same. This indicates that listing is a good substitute for plowing in summer fallowing.

RESULTS WITH SPRING WHEAT

Spring wheat (durum) has been grown at the station continuously on the same ground on fall plowing and on spring plowing, in rotations on fall plowing and on spring plowing after oats and after corn, on disked corn ground, and on fallow. The yields of spring wheat for the years 1915 to 1929, inclusive, together with the 15-year averages are shown in Table 6.

TABLE 6.—*Yields of spring wheat (durum) grown by different methods at the Colby branch station, 1915–1929*

Treatment and previous crop	Number of plots averaged	Acre yield (bushels)															
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average
Spring plowed:																	
Spring wheat (continuous)	1	17.2	2.0	0	0.3	16.0	6.2	5.8	4.9	13.5	1.1	4.2	0	1.3	7.2	4.5	5.6
Oats	1	25.8	.2	0	1.0	14.2	2.2	9.7	6.9	9.0	5.9	3.5	0	2.7	14.5	2.8	6.6
Corn	1	27.0	1.3	0	.8	15.7	8.0	12.5	7.5	9.3	1.5	6.3	0	2.2	11.2	6.8	7.3
Early fall plowed:																	
Spring wheat (continuous)	1	26.8	5.3	0	1.0	13.7	8.3	12.5	8.0	16.0	2.2	1.8	0	.8	7.3	2.7	7.1
Oats	2	25.8	3.0	0	2.1	15.5	5.0	11.9	9.0	12.7	3.0	2.1	0	2.3	12.4	1.8	7.1
Late fall plowed: Corn	1	26.8	.2	0	.7	12.2	3.1	10.5	3.8	7.3	1.7	1.8	0	.8	8.3	1.5	5.2
Disked: Corn	1	26.8	5.2	0	.5	12.3	5.7	8.0	6.6	13.7	1.7	2.3	0	1.3	9.8	7.8	6.8
Fallow	2	24.2	4.8	0	5.2	16.1	16.4	9.9	11.5	14.2	6.0	11.6	4.0	3.5	7.5	8.5	9.6

For the 15-year period spring wheat grown continuously on spring plowing averaged 5.6 bushels, and that on fall plowing 7.1 bushels. The yields after oats averaged 6.6 bushels on spring plowing and 7.1 bushels on fall plowing. After corn the yields averaged 7.3 bushels on spring plowing, 5.2 bushels on fall plowing, and 6.8 bushels on disking. On fallow the average was 9.6 bushels, 2.3 bushels more than the highest average on the cropped-land plots.

All the yields are so low in comparison with those of other crops as to indicate that spring wheat is not adapted to this section. It is the only crop tried in these experiments that did not give a creditable yield after summer fallow.

The yield of spring wheat on fallow is less than half that of winter wheat. The highest average yield for spring wheat on cropped land is 7.3 bushels, which is 1.9 bushels less than the lowest yielding method for winter wheat and 3.7 bushels less than the highest yield for winter wheat on cropped land for the same 15-year period.

RESULTS WITH OATS

Oats have been grown continuously on the same ground on fall plowing and on spring plowing, in rotations after spring wheat on fall plowing and on spring plowing, after barley on fall plowing, and after

corn on spring plowing, on disking, and on fallow. The annual and average yields for the 15 years from 1914 to 1929 are given in Table 7.

TABLE 7.—*Yields of oats grown by different methods at the Colby branch station, 1915–1929*

Treatment and previous crop	Number of plots averaged	Acre yield (bushels)															
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average
Spring plowed:																	
Oats (continuous)	1	37.5	4.7	0	0	34.1	21.9	18.1	12.7	42.5	12.7	11.3	0	12.2	28.8	15.9	16.8
Spring wheat	1	33.1	9.1	0	0	27.2	37.8	21.3	17.3	57.5	16.1	14.7	0	15.6	17.2	13.1	18.7
Corn	2	47.0	2.5	0	0	13.0	26.1	19.9	5.4	37.1	12.7	5.8	0	4.2	13.8	8.9	13.1
Early fall plowed:																	
Oats (continuous)	1	53.4	6.6	0	0	27.5	26.9	17.2	19.8	45.0	17.2	8.1	0	8.4	40.6	8.4	18.6
Spring wheat	2	46.3	4.7	0	0	23.8	34.0	21.5	18.5	43.9	14.4	5.3	0	3.9	25.6	9.2	16.7
Do [1]	1	57.2	5.9	0	0	27.8	28.8	32.2	18.9	41.9	25.5	5.9	0	8.4	28.1	8.8	19.3
Barley	1	41.3	5.0	0	0	14.1	28.1	23.6	5.5	42.5	12.7	2.5	0	3.1	18.8	6.9	13.6
Disked: Corn	1	48.8	8.1	0	0	23.8	35.9	21.6	25.8	31.6	13.6	5.6	0	6.9	18.1	20.6	17.4
Fallow	2	65.2	10.4	0	0	26.4	49.9	33.2	27.7	65.3	26.7	30.7	3.6	13.1	46.7	21.4	28.0

[1] Spring wheat preceded by fallow.

For the 15-year period oats grown continuously on spring plowing averaged 16.8 bushels and on fall plowing 18.6 bushels. Oats in a rotation on spring plowing after spring wheat averaged 18.7 bushels. Oats on fall plowing after spring wheat in two 3-year rotations in which the land is cropped every year averaged 16.7 bushels.

In a 3-year rotation in which oats were sown on fall plowing after spring wheat on fallow, the oats averaged 19.3 bushels, or 2.6 bushels more than in the rotation where the land is cropped every year. This suggests that the effect of the fallow sometimes carries over into the second year.

Oats on early fall plowing after barley averaged 13.6 bushels. Oats on spring plowing after corn averaged 13.1 bushels. On disked-corn ground the oats averaged 17.4 bushels, or 4.3 bushels more than on spring plowing.

Oats grown on fallow averaged 28 bushels. This is almost one and a half times as much as the highest yield on ground cropped the previous year.

RESULTS WITH BARLEY

Barley has been grown continuously on the same ground on fall plowing and on spring plowing, in 3-year rotations after oats on spring plowing and on disked-corn ground, and on fallow, as well as in 4-year rotations on disked corn and milo ground. The annual and average yields from 1915 to 1929 are given in Table 8.

During the 15-year period from 1915 to 1929, continuous barley averaged 19.5 bushels on spring plowing and 21 bushels on fall plowing. Fall plowing was done to a depth of 7 to 8 inches immediately following the removal of the crop after harvest. This ground was disked in the spring before seeding. Spring-plowed land was plowed to a depth of 3 to 4 inches and usually harrowed or disked just before seeding.

TABLE 8.—*Yields of barley grown by different methods at the Colby branch station, 1915–1929*

Treatment and previous crop	Number of plots averaged	Acre yield (bushels)															
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average
Spring plowed:																	
Barley (continuous)	1	42.3	2.3	0	4.4	37.5	29.2	18.1	19.1	43.3	14.8	13.5	0	9.8	36.5	21.7	19.5
Oats	1	43.8	0	0	3.5	44.4	22.5	21.0	12.5	46.0	22.1	13.3	0	6.7	40.0	22.3	19.9
Early fall plowed: Barley (continuous)	1	41.7	14.8	0	7.1	42.7	27.5	25.2	32.5	36.0	20.0	8.3	0	1.9	45.2	12.7	21.0
Disked:																	
Corn	1	52.9	7.9	0	2.1	44.4	16.7	15.2	6.4	37.3	15.0	3.5	0	5.6	41.7	17.9	17.8
Do	1	----	----	----	----	----	26.0	1.0	13.2	17.9	8.2	9.8	0	2.1	39.6	20.2	[1] 13.8
Milo	1	----	----	----	----	----	22.7	4.2	14.4	14.6	5.9	18.5	0	1.5	42.1	27.3	[1] 15.1
Fallow	1	61.9	20.8	0	11.7	52.5	55.0	35.3	36.3	54.4	40.4	35.8	8.1	21.0	52.7	51.7	35.8

[1] 10-year average.

In a 3-year rotation barley on spring plowing after oats averaged 19.9 bushels, almost the same as continuous barley on spring plowing.

Barley on disked corn ground averaged 17.8 bushels, or 2.1 bushels less than on spring plowing after oats. This is surprising in view of the fact that the common farm practice is to grow barley after corn without plowing. It is the popular belief that this method is not only cheaper but returns better yields. In these rotations the corn is cut in the fall and the stalks removed. The adjoining plots, being in small-grain stubble, catch and hold snow, whereas the bare corn ground holds the snow only when there is no wind to cause drifting, which is seldom. If the stalks were left in the field, it is reasonable to suppose that the yields on the disked corn ground would be higher than they are.

Barley on fallow averaged 35.8 bushels, 1.7 times as much as on the best continuously cropped land. This indicates that seeding barley on fallow land is justified when the fallow land is available.

Two similar 4-year rotations were started in 1919. In one barley is grown after corn, and in the other it is grown after milo. For the 10 years from 1920 to 1929 the barley after milo averaged 1.3 bushels more than that after corn. The stalks of both the milo and the corn were removed in the fall, so that neither plot caught much snow. A good stand of corn was secured each year, but in some years the stand of milo was so thin that the ground was partially fallow.

Measured in bushels, barley has outyielded oats by 7.8 bushels on fallow, by 2.7 bushels on continuous spring plowing, by 2.4 bushels on continuous fall plowing, and by 0.4 of a bushel on disked corn ground.

Measured in pounds of grain, barley has averaged 92 per cent more than oats on fallow, 74 per cent more than oats on continuous spring plowing, 69 per cent more than oats on continuous fall plowing, and 53 per cent more than oats on disked corn ground.

RESULTS WITH CORN

Corn has been grown continuously on the same ground on spring plowing, on fall plowing, on fall plowing and subsoiling, and on listing both with and without previous disking. In rotations it has been

grown on spring plowing after spring wheat, oats, and barley; on fall plowing after spring wheat and oats; and on listing in 40-inch and 80-inch rows after milo and winter wheat. It has also been alternated with fallow. Where the ground was plowed or fallowed, the corn was planted with a surface planter. The annual and average yields from 1915 to 1929, inclusive, are given in Table 9.

TABLE 9.—*Yields of corn grown by different methods at the Colby branch station, 1915–1929*

Treatment and previous crop	Number of plots averaged	Acre yield (bushels)															
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average
Spring plowed:																	
Corn (continuous)	1	55.4	0	0	0	26.3	38.7	16.3	19.2	38.0	2.4	0	0	15.6	22.4	1.7	15.7
Spring wheat	1	40.7	0	0	0	19.9	59.3	23.9	18.0	51.0	14.7	0	0	8.5	15.6	.4	16.8
Oats	1	52.9	0	0	0	32.8	65.2	30.7	27.8	55.8	17.9	10.3	0	11.9	24.7	1.5	22.1
Barley	1	42.7	0	0	0	17.5	47.7	18.1	14.9	50.2	10.6	0	0	3.6	13.1	.3	14.6
Late fall plowed: Corn (continuous)	1	59.1	0	0	0	27.2	51.9	16.9	14.4	44.6	1.2	0	0	10.1	17.2	.7	16.2
Late fall plowed and subsoiled: Corn (continuous)	1	65.0	0	0	0	26.0	56.5	19.9	15.0	43.9	2.2	0	0	15.2	19.5	.8	17.6
Early fall plowed:																	
Spring wheat	1	46.1	0	0	0	22.6	61.6	25.7	21.6	37.1	3.6	0	0	8.4	21.6	.5	16.6
Oats	3	44.2	0	0	0	19.5	52.9	21.4	15.3	39.2	3.8	0	0	2.7	16.9	.5	14.4
Disked and listed: Corn (continuous)	1	42.1	2.0	3.0	6.0	29.4	53.9	25.6	30.0	53.9	12.4	2.3	0	20.3	24.5	7.7	20.9
Listed:																	
Corn (continuous)	1	44.1	2.6	3.9	3.2	31.5	45.7	23.7	28.5	47.5	15.6	3.1	0	21.6	22.7	5.5	19.9
Milo [1]	1	13.4	1.1	2.7	0	13.2	35.3	13.7	13.2	30.7	5.1	0	0	12.8	10.3	2.4	10.3
Winter wheat [1]	1	23.0	.9	2.1	0	16.5	29.5	16.1	16.4	33.1	10.5	1.9	0	16.9	10.9	4.4	12.1
Milo	1	----	----	3.6	0	23.2	53.1	21.4	13.5	50.5	4.5	4.8	0	9.1	18.7	7.6	[2] 16.2
Winter wheat	1	----	----	2.4	0	25.3	50.3	30.7	31.7	48.1	8.5	5.7	0	8.4	17.3	3.2	[2] 17.8
Do	1	----	----	----	----	----	42.5	20.0	21.0	39.3	8.3	0	0	11.9	19.2	2.0	[3] 16.4
Fallow	1	64.4	3.6	4.9	6.9	43.6	52.7	36.7	37.9	56.4	21.6	14.0	0	24.4	36.9	23.1	28.5

[1] Corn planted in 80-inch rows. [2] 13-year average. [3] 10-year average.

Continuous corn averaged 15.7 bushels on spring plowing, 16.2 bushels on fall plowing, 17.6 bushels on fall plowing and subsoiling, 19.9 bushels on listing, 20.9 bushels on listing with previous disking, and 28.5 bushels in alternation with fallow. Corn in rotations averaged 15.5 bushels on fall plowing and 17.8 bushels on spring plowing.

Where cropped to corn continuously the yield was slightly higher on fall plowing than on spring plowing, but where corn followed small grain the reverse was true. The cornstalks being removed in the fall, nothing is left to catch the snow on the corn ground to be plowed in the spring, whereas the grain stubble on the plots to be plowed in the spring catches and holds the snow. It is probable that this one factor accounts for the differences in yield.

Corn grown continuously on listed ground averaged 20.4 bushels, while continuous corn surface planted on both fall and spring plowed ground averaged 16 bushels, the difference being 4.4 bushels in favor of listing.

Listing has been surer than plowing and surface planting. In plowing and surface planting, corn was a total failure on all the plots, with a single exception, in 5 of the 15 years. Listed corn failed completely only once, in 1926, and outyielded the surface planting in 13 of the 15 years. The surface-planted corn outyielded the listed in 1915, a wet year, when exceptionally high yields were obtained

from all the plots. In 1923, however, the listing outyielded the surface planting, although it was a wet year with high yields.

For continuous listed corn there was a difference of 1 bushel in favor of disking before listing over listing without disking.

Yields on fallow averaged about a third more than on the best cropped land.

Corn listed in 80-inch rows averaged 11.2 bushels for the 15 years, and corn listed in regular 40-inch rows averaged 20.4 bushels, or 82 per cent more.

In 1917 two 4-year rotations were added. In one of these corn is listed after winter wheat, and in the other it is listed after milo. On an average for the 13 years the corn yielded 17.8 bushels after wheat and 16.2 bushels after milo.

RESULTS WITH MILO

Milo has been grown continuously on the same ground after fall plowing, spring plowing, fall plowing and subsoiling, listing without previous cultivation, and listing with previous disking. It has also been planted in alternation with fallow and in rotations after rye for green manure, after peas for green manure, listed on alternate-rowed corn ground, and listed after wheat. On plowed, green-manured, and fallowed ground the milo is planted with a surface planter. The annual and average yields from 1915 to 1929, inclusive, are given in Table 10.

TABLE 10.—*Yields of milo grown by different methods at the Colby branch station, 1915–1929*

Treatment and previous crop	Number of plots averaged	Acre yield (bushels)															
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1923	1929	Average
Spring plowed: Milo (continuous)	1	11.4	0	3.4	7.1	27.6	18.3	15.7	17.0	30.9	4.7	6.0	0	5.0	11.2	1.7	10.7
Fall plowed: Milo (continuous)	1	12.6	0	3.1	9.1	28.8	20.7	15.9	12.3	44.8	6.7	1.6	0	7.9	11.7	1.4	11.8
Fall plowed and subsoiled: Milo (continuous)	1	5.9	0	5.4	9.1	14.7	21.4	26.0	12.8	48.3	9.1	5.2	0	9.7	9.5	4.3	12.1
Disked and listed: Milo (continuous)	1	0	0	0	7.9	31.7	23.8	11.2	23.9	29.0	6.1	10.7	0	3.4	1.6	7.4	10.4
Listed:																	
Milo (continuous)	1	0	0	0	8.3	32.8	18.8	10.2	16.1	27.2	1.7	15.9	0	5.9	.7	7.1	9.6
Corn, 80-inch rows	1	0	0	0	6.9	31.2	25.3	26.3	13.2	27.2	5.1	15.7	0	9.8	3.6	2.2	11.1
Winter wheat	[1] 23	0	0	1.3	3.4	33.5	20.5	20.2	17.5	41.7	3.9	6.2	0	7.2	6.5	4.7	11.1
Green manure:																	
Winter rye	2	4.3	0	4.3	17.6	32.8	54.6	36.9	31.3	52.5	27.8	7.5	0	19.0	17.0	13.6	21.3
Peas	1	4.8	0	9.3	17.2	29.5	53.1	36.5	37.4	50.3	28.8	18.1	0	12.1	21.6	16.6	22.4
Fallow	3	7.0	0	8.8	12.7	26.2	53.7	48.8	38.0	67.1	39.5	24.7	0	13.4	19.7	21.6	25.4

[1] 22 plots until 1920.

Continuous milo for the 15-year period from 1915 to 1929 averaged 10.7 bushels on spring plowing, 11.8 bushels on fall plowing, 12.1 bushels on fall plowing and subsoiling, 9.6 bushels on listing without previous cultivation, and 10.4 bushels on listing with previous disking. Listed milo following alternate-rowed corn averaged 11.1 bushels, and 23 plots listed on winter-wheat stubble averaged the same.

Two plots following rye for green manure averaged 21.3 bushels, and one with peas as green manure averaged 22.4 bushels. Three plots on fallow averaged 25.4 bushels. One of the fallow plots was

manured, but, as has been stated in considering the yields of winter wheat, this did not occasion any significant difference in the yield of milo. Yields on fallow averaged 2.1 times as much as on the highest-yielding continuous-cropping method.

The yield of continuous milo listed with previous disking averaged 0.8 of a bushel more than the adjacent plot listed but not disked.

Aside from the yields on green-manure and fallow plots, which were surface planted, there is no great difference between the average yields of listed and surface-planted plots, although the surface-planted plots averaged slightly more.

The chief difficulties with milo seem to be in getting a stand and in getting the crop to mature before frost. Usually the better stand is secured with surface planting. The seed germinates quicker, and the crop matures earlier, but it suffers more from drought in the summer. Stands of listed milo often are very thin, and while the crop grows slower in the spring and matures later, it stands the dry weather better.

The use of manure was studied in ten 3-year rotations of fallow, winter wheat, and milo. In one of these straw was applied at the rate of 3 tons to the acre as a top-dressing to the wheat. In two others the wheat was top-dressed with barnyard manure at the rates of 3 and 6 tons to the acre, respectively. The 15-year average yields of milo following wheat in these three rotations were 11.6, 10.7, and 10 bushels to the acre, respectively, the average for the three being 10.8 bushels.

In four other rotations barnyard manure was applied to the wheat stubble at the rates of 3, 6, 9, and 12 tons to the acre, previous to listing the milo. The yields were 10.4, 12.3, 12.0, and 12.4 bushels to the acre, the four averaging 11.8 bushels.

The other three rotations were unmanured checks. The milo in them yielded 12.4, 9.7, and 11.9 bushels, the three averaging 11.3 bushels. This is half a bushel more than the average of the plots where straw and manure were applied as top-dressings to the wheat preceding the milo, and half a bushel less than the average where manure was applied just before the milo was listed. The differences between the manured and the unmanured rotations are less than those among the check plots. Careful analysis of the data indicates that the straw and manure have had no measurable effect on the yields of milo.

In a series of 3-year rotations of fallow, winter wheat, and milo, the results from the use of eight methods of preparing wheat-stubble land for milo by listing have been compared for the 15 years from 1915 to 1929. The methods used were: Listed in the fall, leveled in the spring, and planted with a lister; disked early after harvest, fall listed, leveled in the spring, and planted with a lister; fall listed and planted by splitting the ridges; fall listed, harrowed in the spring, and listed in the same furrows; fall listed, harrowed in the spring, and planted by splitting the ridges; early spring listed and planted in the furrows without cultivation; disked in the spring and planted with a lister; and planted with a lister without cultivation.

The lowest average yield by any of the methods was 9.6 bushels, and the highest average was 13.2 bushels.

The best yields as well as the best stands were obtained on the plots that were listed in the fall and leveled in the spring. Of these,

the one disked early after harvest averaged a fraction of a bushel more than any of the others. The volunteer wheat and weeds were controlled almost completely in this case, whereas there were usually some of both present on the other plots.

Practically as good a stand and almost the same yield, 12.4 bushels, were obtained where the ground was listed in the fall, harrowed down in the spring, and the milo planted by splitting the ridges. Where the planting was done by nosing out the original furrows the stands were virtually the same, but the yields averaged 1.6 bushels less than where the ridges were split.

Where the ground was fall listed and the planting done by splitting the ridges without harrowing in the spring, only three-fourths as much of a stand was secured on an average as where the ridges were harrowed in the spring, and the yield was 1.3 bushels less. Where the planting was done by splitting the ridges without previous spring cultivation, the seed bed was usually drier and more cloddy than that resulting from the use of any other method, except where no cultivation whatever was given before planting with the lister.

The poorest average yield, 9.6 bushels, and the poorest stand resulted where no cultivation whatever was given previously to planting the milo with a lister. Ordinarily, by milo-planting time the volunteer wheat and weeds have made considerable growth and used a large amount of moisture, and often they are not all killed by the lister. The seed bed is usually comparatively dry and cloddy.

Where the wheat stubble was disked early in the spring somewhat better stands were secured, and the yields averaged 1.6 bushels more than where no previous cultivation was given. By using this method much of the volunteer wheat is killed and the weeds are kept back so that they do not use up the moisture before seeding time.

Where the ground was listed in the spring and the milo planted in the same furrows without further cultivation, almost as good stands were secured as by the use of any of the other methods, but the yields were next to the lowest. When this method is employed, the weeds are troublesome both in the furrows and on the ridges at seeding time, and they use moisture needed by the young plants. After early spring listing, throwing in the ridges or some similar treatment to eliminate the weeds seems essential.

In the rotations where milo following winter wheat was planted with a lister without previous cultivation the yield averaged the same, 9.6 bushels, as where milo was grown continuously by the same method.

Where the ground was disked in the spring previous to planting with a lister, the yield after winter wheat averaged 0.8 of a bushel more than where milo was grown continuously.

Where milo was grown after winter wheat, volunteer wheat and weeds were more troublesome than where milo was grown continuously. However, where the milo is harvested with a binder, as in these experiments, the wheat stubble catches much more of the snow that falls during the winter than does the milo stubble. The wheat-stubble ground usually contains more moisture in the spring than the milo ground. If this moisture is saved by killing the volunteer wheat and the weeds before they have made much growth, the yield of milo is likely to be greater where it is grown after winter wheat. If the volunteer wheat and weeds are allowed to grow, they often use up more than the additional moisture stored in the wheat stubble

during the winter. This is especially true with a crop like milo, which is usually not planted before June.

Milo listed in alternate-rowed corn stubble averaged 11.1 bushels, which is 0.2 of a bushel less than the average of all the listed plots. While this is a negligible difference, it indicates that alternate-rowed corn ground does not act as a partial fallow with milo, which is planted late in the spring, as it does with winter wheat planted in the fall.

In all instances corn has on an average yielded higher than milo when both were grown according to the same method. The difference between the two in favor of corn is least on fallow, where it amounts to only 12 per cent of the yield of milo. On the continuous-cropping plots the yields of corn averaged from about a third more to double the yields of milo.

RESULTS WITH KAFIR

Kafir has been grown continuously on the same ground on spring plowing and on fall plowing and alternately with fallow. All plots are surface planted. The yields from 1915 to 1929, inclusive, are given in Table 11.

TABLE 11.—*Yields of kafir, feterita, and beans grown by different methods at the Colby branch station for years specified, 1915–1929*

Crop, treatment, and previous crop	Number of plots averaged	Acre yield (bushels)															
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average
Kafir																	
Spring plowed: Kafir (continuous)	1	0	0	0	9.5	26.2	32.7	22.8	7.1	27.5	0.9	1.3	0	9.2	8.2	0	9.7
Fall plowed: Kafir (continuous)	1	0	0	0	6.7	22.0	28.7	24.8	1.2	35.1	3.4	1.0	0	14.3	6.5	0	9.6
Fallow	1	0	0	0	12.0	28.0	25.7	33.1	22.3	35.8	27.0	28.2	1.7	28.3	11.7	22.8	18.4
Feterita																	
Listed: Feterita (continuous)	4	----	----	2.7	3.0	0	0	4.9	16.8	14.1	0	21.5	0	13.1	7.0	6.6	6.9
Pinto beans																	
Spring plowed: Winter wheat	1	----	----	----	----	----	6.3	7.8	3.4	19.3	3.8	1.8	0	3.3	4.7	0	5.0

Kafir averaged 9.7 bushels on spring plowing, 9.6 bushels on fall plowing, and 18.4 bushels on fallow for the 15 years from 1915 to 1929. The yields on fall plowing and on spring plowing were practically equal. The average yield on fallow was almost twice as great.

Continuous milo outyielded continuous kafir 1 bushel on spring plowing, 2.2 bushels on fall plowing, and on comparable plots in alternation with fallow milo outyielded kafir 5.7 bushels. Kafir seldom matured fully before frost.

RESULTS WITH FETERITA

Feterita has been grown since 1917 on four plots. It is listed continuously on the same ground. The 13-year (1917–1929) average of the four plots is 6.9 bushels per acre. (Table 11.) For the same 13 years continuously listed milo averaged 11.1 bushels. It is difficult to get a good stand with feterita, as with milo, but unlike milo and kafir it usually matures fully before frost.

STOVER YIELDS OF CORN, MILO, AND KAFIR

Table 12 gives the average yields of stover of corn, milo, and kafir grown on spring plowing and on fall plowing and in alternation with fallow.

TABLE 12.—*Average acre yields of stover*[1] *of corn, milo, and kafir grown by different methods at the Colby branch station, 1915–1929*

Crop	Spring plowing	Fall plowing	Fallow
	Pounds	*Pounds*	*Pounds*
Corn	1,426	1,414	2,287
Milo	1,787	2,147	4,011
Kafir	3,242	3,346	5,571

[1] Stover is the total crop minus the ears of corn or the threshed grain of milo and kafir.

Taking kafir as a 100 per cent basis, on spring plowing the stover yield of corn averaged 44 per cent and that of milo 55 per cent. On fall plowing the stover yield of corn averaged 42 per cent and that of milo 64 per cent as much as that of kafir. On fallow the stover yield of corn averaged 41 per cent and that of milo 72 per cent as much as that of kafir. All the kafir plots averaged decidedly more stover than those of corn or milo.

RESULTS WITH PINTO BEANS

Beginning with 1920, pinto beans have been grown in a 2-year rotation with winter wheat. They are planted with a surface planter in 40-inch rows on spring plowing. The average yield for 10 years was 5 bushels. In 1926 and 1929 the crop was a complete failure. The annual yields are shown in Table 11.

RYE AND PEAS FOR GREEN MANURE

In one 4-year rotation milo is planted after rye for green manure, and in a similar rotation it is planted after field peas for green manure. Rye is drilled in the fall, and the peas are drilled early in the spring on fall plowing. Each is turned under when it begins to bloom. Milo averaged 22.2 bushels after rye and 22.4 bushels after peas for the 15 years from 1915 to 1929. During the same period milo following rye green manure in another rotation not so closely comparable averaged 20.3 bushels. If there are any cumulative effects resulting from the green-manure crops they have not yet become apparent.

RESPONSE OF CROPS TO FALLOW

Fallow has increased the average yields over those produced by the highest-yielding methods on cropped land, not including winter wheat following corn in alternate rows, as follows: Winter wheat, 96 per cent; spring wheat, 32 per cent; oats, 45 per cent; barley, 70 per cent; corn, 29 per cent; milo, 110 per cent; and kafir, 90 per cent.

The 15-year average yields of the different crops after fallow are as follows: Winter wheat, 21.6 bushels; spring wheat, 9.6 bushels; oats, 28 bushels; barley, 35.8 bushels; corn, 28.5 bushels; milo, 25.4 bushels; and kafir, 18.4 bushels.

Spring wheat is the only crop that has not given a creditable yield on fallow.

SUMMARY

The yields of winter wheat on fallow averaged about twice as much as yields on plots prepared in any other way, with the exception of the yields following rye green manure, corn in 80-inch rows, and beans in 40-inch rows. Green manure is a fallow after the crop is plowed under. It gave yields comparable with those on fallow but is more expensive. Corn in 80-inch rows and beans in 40-inch rows did not fully utilize the ground. Such cropping partakes somewhat of the nature of a fallow.

The best method of fallow under trial was plowing in May, before vegetation had made enough growth to reduce materially the water content of the soil, and cultivating enough to keep the ground clean during the remainder of the season. Plowing in the fall and leaving the ground rough over winter gave almost as good average yields, but such treatment exposes the soil to the danger of blowing. Delaying the spring plowing for fallow until late June without previous cultivation resulted in a decrease of 6 bushels in yield. Plowing wheat stubble for fallow as early as practicable after harvest and intensive cultivation during the entire fallow period, with or without a second plowing in June, resulted in a decrease of about 2 bushels of wheat per acre. Listing was practically equal to plowing under comparable conditions as a method of handling fallow. The catching and holding of snow and the protection of the soil from blowing are important considerations; and methods of fallow that leave the ground in stubble, rough, or in ridges over winter are to be preferred to those that leave it bare and smooth.

Aside from fallows and partial fallows, there was no great difference in the results when other methods of preparation for winter wheat were used. Listing barley stubble gave somewhat higher yields than plowing it, because it controlled volunteer barley better. Methods such as stubbling in, which would seem very poor, ranked with the others because of their efficiency in catching and holding snow and in protecting the wheat during the winter and spring.

Barnyard manure plowed under and barnyard manure and straw used as top-dressing on winter wheat did not have any apparent influence on yields.

All yields of spring wheat were so low as to indicate that it is not adapted to northwestern Kansas. On fallow the yield of spring wheat is less than half that of winter wheat.

There was no great difference in the yields of oats on fall plowing, spring plowing, and drilling in corn stubble, but on summer fallow the yields were 45 per cent greater than the best yield following another crop.

Barley was a much heavier yielding crop than oats and responded well to fallow. There was little difference in the yields of barley on ground prepared in other ways.

Listed corn yielded more than plowed and surface-planted corn and was less likely to suffer total failure. Disking in the spring before listing increased the yield 1 bushel per acre. Corn listed in alternate rows averaged only 55 per cent as much grain as corn listed in ordinary 40-inch rows.

Surface-planted milo averaged a little better than listed milo. The yields of milo on fallow were more than double those on the best

continuously cropped plots. The yields of milo after green manure were appreciably less than on fallow.

Kafir seldom matured before frost. The yields on fallow were almost twice as great as on land cropped the year before. There was little difference in the yields on spring-plowed and on fall-plowed land.

It is difficult to get a good stand of feterita, but the grain usually matures fully before frost.

Corn has had higher average yields of grain than milo under every method tested. On comparable plots milo has averaged from about 1 to 6 bushels more grain than kafir and 3 bushels more than feterita.

The yields of stover have had the following average ratios: Kafir, 100; milo, 64; and corn, 42.

Pinto beans in rotation with wheat averaged 5 bushels per acre.

No difference was apparent in the results from rye and field peas as green-manure crops. No cumulative effects of their use are evident.

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